Preliminary Studies of the Gastrointestinal Tract with Colloidal Barium

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SUMMARY

A stable colloidal suspension of barium sulfate has been developed and tested in roentgen examination of the gastrointestinal tract. The new material is rather distinctive in radiographic appearance and can usually be differentiated from simple barium-water mixtures by inspection of roentgenograms of the opacified stomach and small intestine. It usually affords a satisfactory demonstration of the mucosal folds of the stomach and duodenal bulb and is considerably more resistant to flocculation and precipitation by retained gastric secretions. In the small intestine, it has little tendency to undergo flocculation and fragmentation, and permits visualization of fine mucosal configurations with unusual clarity. Its motility is about the same as that of conventional suspensions. Air contrast colon examinations with the colloidal preparation exhibit a very uniform, opaque, and stable coating of the bowel wall and are more consistently satisfactory than when simple barium-water mixtures are used.

FOR many years radiologists have been seeking an opaque medium with which consistently better visualization of the gastrointestinal tract might be obtained than with the usual suspension of barium sulfate in water. Such suspensions are labile under a variety of conditions; flocculation and precipitation of the barium may occur suddenly as a result of dilution, dehydration, or change in pH. These shortcomings are especially noticeable during examination of the small intestine, air contrast examination of the colon, and attempted demonstration of gastric mucosal folds.

The ideal medium would provide a uniform, smooth, radiopaque coating over the bowel wall; would mix readily with retained secretions of the stomach, intestine, and colon; would not be influenced by variation in pH, by contact with mucous secretion, or by the action of the digestive enzymes; would pass freely and promptly through the bowel with no tendency to break up into isolated collections, to precipitate out of suspension, or to become inspissated and impacted. In addition, the medium must of course be non-toxic, palatable, convenient to use, and inexpensive.

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DESCRIPTION OF THE COLLOIDAL MEDIUM

In 1949 one of the authors (Windholz) was instrumental in the development of a stable colloidal aqueous suspension of barium sulfate. This preparation is now available in two forms: a viscous concentrated suspension, for examination of the upper gastrointestinal tract, and a less viscous, dilute suspension for use in opaque enemas.*

The medium for use in the upper gastrointestinal tract is about the consistency of heavy cream. It remains in suspension indefinitely, requiring only slight shaking before use if it has been standing more than a few days. It resists precipitation by saliva and gastrointestinal secretions (it will precipitate slightly when mixed with retained gastric secretions but is much less subject to this fault than the usual barium sulfate and water mixtures). It forms a readily visible (although thin), uniform, unbroken coating over the stomach or bowel wall which gives an unusually good silhouette of the mucosal surface, especially when air is present to provide a double contrast. In addition, it tends to remain in a single column which in many cases may extend from stomach to colon. Segmentation and flocculation are minimal. The material resists desiccation and remains fluid in its passage through the alimentary tract. Constipation has not been a source of complaint. The material has no food value and is tasteless; however, vanilla or other flavoring is usually added by the manufacturer to make it more palatable. The medium for colonic use is similar but more fluid and considerably less dense.

PROCEDURE AND RESULTS

Clinical evaluation of the new medium was carried out in the Department of Radiology, Stanford University Hospitals. Two rooms were provided with identical radiographic-fluoroscopic equipment. The colloidal material was used in one of these rooms and the usual barium sulfate and water mixture in the other. The two rooms did not receive an exactly equal number of patients, but no attempt was made to select patients for examination with one medium or the other.

After the medium had been in use about four months, two of the authors (Kaplan and Jones) re-

*Made by the Pacific Chemical Company, 617 Montgomery Street, San Francisco, under the trade name "Baridol."

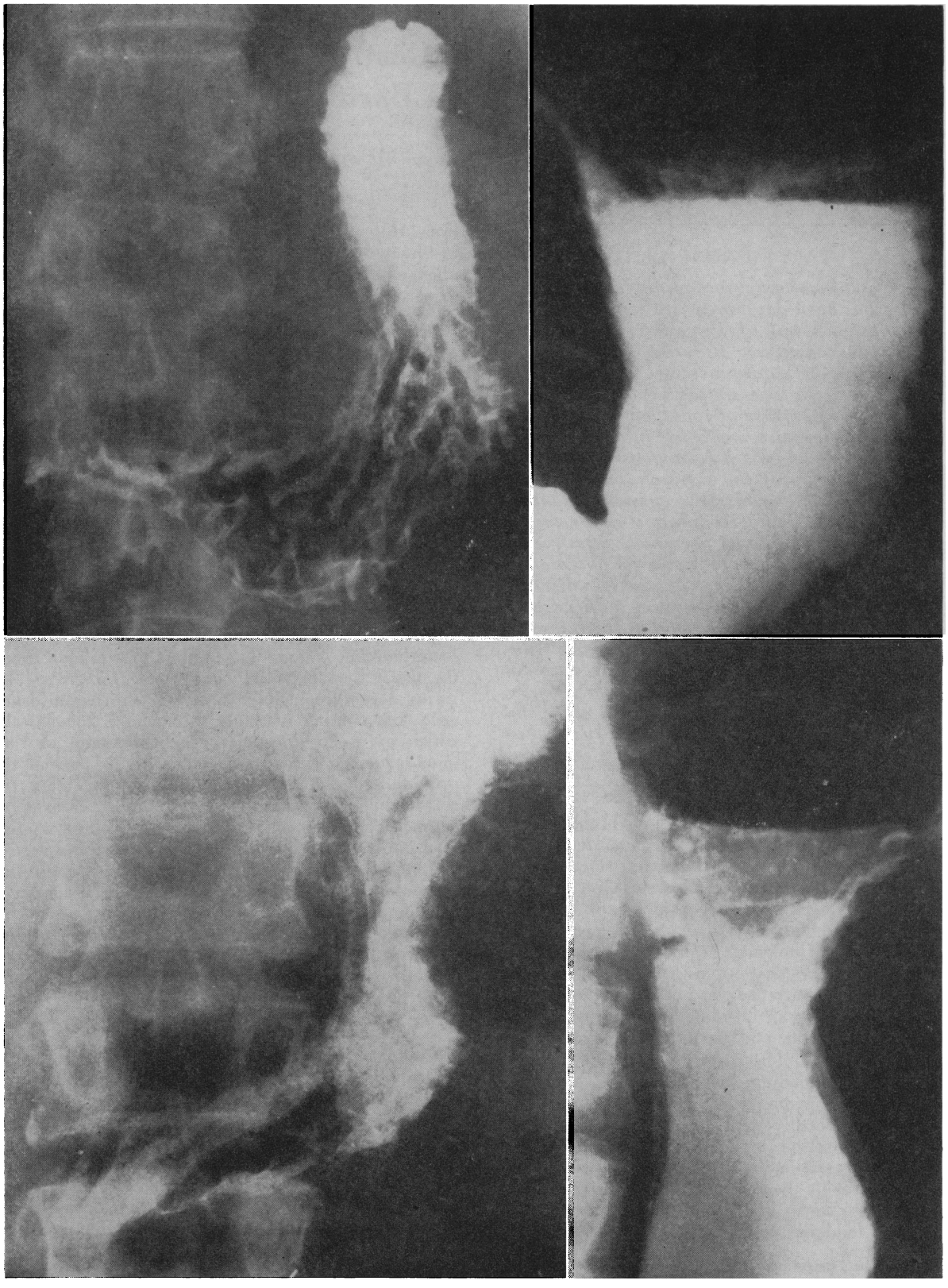

Figure 1.—*Upper left:* Good spot film demonstration of gastric mucosal pattern with colloidal barium despite *(upper right)* retained fluid in stomach seen layered above barium on erect spot films. *Lower left:* Prompt precipitation of conventional barium-water suspension in amorphous flocculated form, obscuring mucosal pattern, in the presence of *(lower right)* retained gastric secretions.

viewed the films in a series of 208 cases with reference to the following items: (1) recognition of type of medium employed; (2) demonstration of the gastric mucosal pattern, filled stomach, filled and compressed duodenal bulb, mucosal pattern of small bowel, distribution and contours of small bowel, and degree of flocculation; and (3) motility of the meal. In the series, the colloidal preparation was used in 137 cases while 71 control cases received the usual barium sulfate suspension in water.

The recognition test was carried out because it was felt that if the new medium were significantly different from conventional barium-water mixtures it should be possible to detect which had been used in a given examination merely by inspection of the films. The results of this test are summarized in Table 1. It can be seen that the colloidal material was seldom mistaken for conventional barium suspensions, but that the converse occurred not infrequently. Review of the latter group revealed that confusion of the two media was almost entirely confined to the group of cases in which ordinary barium-water mixtures had given relatively optimal results.

Qualitative evaluation of each case was made at the time of the recognition test, before the medium actually used in that case was revealed. Some of the collected observations are presented in Table 2. Both media gave satisfactory opacification of the filled stomach. Gastric mucosal folds were well demonstrated in a greater percentage of cases when the colloidal material was used, although visualiza-

TABLE 1.—*Colloidal Barium Recognition Test*
(208 Examinations of Upper Gastrointestinal Tract)

In 71 cases *barium in water* was used. In review of the films:	
50%	were recognized as *barium in water* in the stomach.
60%	were recognized as *barium in water* in the small intestine.
35%	were mistaken for *colloidal barium* in the stomach.
25%	were mistaken for *colloidal barium* in the small intestine.
15%	were indeterminate or incomplete.
In 137 cases *colloidal barium* was used. In review of the films:	
90%	were recognized as *colloidal barium.*
5%	were mistaken for *barium in water.*
5%	were indeterminate or incomplete.

Figure 3.—Partially "pressed out" normal duodenal bulb showing longitudinal mucosal folds as revealed by colloidal barium.

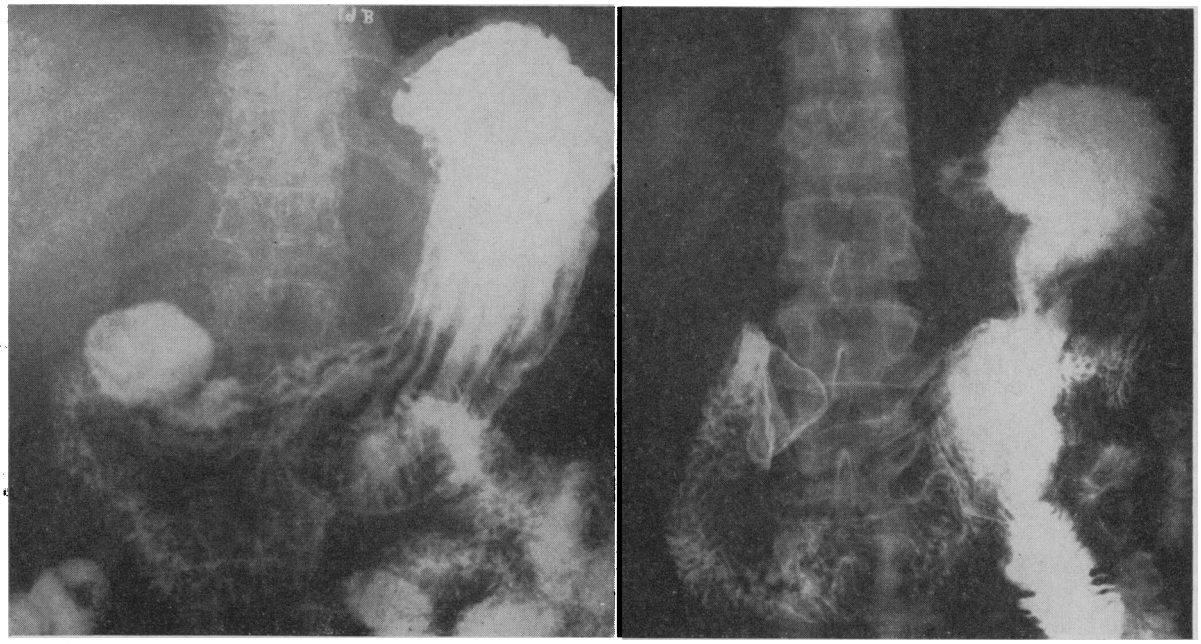

Figure 2.—Double contrast visualization of antral portion of stomach coated with colloidal barium in supine projection. In the film at the right, the duodenal bulb is similarly demonstrated.

TABLE 2.—*Mucosal Pattern Evaluation*

	Good	*Fair*	*Poor*
STOMACH:			
Barium in water	60%	25%	15%
Colloidal barium	70%	20%	10%
DUODENAL BULB*:			
Barium in water	50%	30%	5%
Colloidal barium	80%	5%	5%
SMALL INTESTINE:			
Plain barium	50%	40%	10%
Colloidal barium	90%	8%	2%

*Evaluated on pressure spot films. Bulb not visualized in remaining cases.

tion was unsatisfactory in 10 per cent of the cases even with this medium. The new material often yielded good mucosal patterns in the presence of retained gastric secretion (Figure 1). It tended to coat the gastric surface rather uniformly, and, in the presence of air, this property often afforded unusual demonstrations of the antrum and corpus in supine projections (Figure 2).

The relative merits of the two media in the duodenal bulb paralleled those in the stomach. The greater film-forming properties of the colloidal material were even more evident, a faint coating being rather consistently observable on compression "spot" films (Figure 3).

In the small intestine, the colloidal suspension provided a pattern quite unlike that usually observed with barium and water mixtures. It formed a smooth uniform coating which outlined the walls and valvulae with great clarity (Figure 4). The tendency to maintain a single column was pronounced, and frequently the entire small bowel from stomach to colon was clearly visualized on a single film (Figure 5). Flocculation and segmentation were minimal (Table 3). Motility did not appear to be significantly different from that of ordinary barium-water mixtures.

The new medium has not been used extensively for opaque enema examination of the colon because its advantageous properties are minimized under these conditions and its greater viscosity delays filling of the colon. It has, however, yielded consistently superior results in double contrast examinations of the large bowel. The technique of this examination is described elsewhere[1] and only those details pertinent to the use of the new medium will be noted here.

The double contrast examination was always done as a separate procedure, not as an immediate sequel to the conventional examination with opaque enema. The "colonic" preparation used initially was felt to be insufficiently opaque and more recently the more

TABLE 3.—*Observations in Small Intestine*

	None	*Slight*	*Moderate to Pronounced*	
FLOCCULATION:				
Barium in water	50%	20%	30%	
Colloidal barium	90%	5%	3% †	
	Single Column	*Slight*	*Moderate*	*Marked*
FRAGMENTATION:				
Barium in water	35%	20%	40%	5%
Colloidal barium	85%	6%	8%	1%
	One Hour	*Two Hours*	*Five Hours*	
MOTILITY*:				
Barium in water	45%	65%	85%	
Colloidal barium	35%	60%	85%	

*Head of meal in cecum or colon at indicated interval.
†In 2 per cent of cases, flocculation was indeterminate.

Figure 4.—Demonstration of intimate details of small intestinal mucosal surface with colloidal barium. Note ileocecal valve region in film at the right.

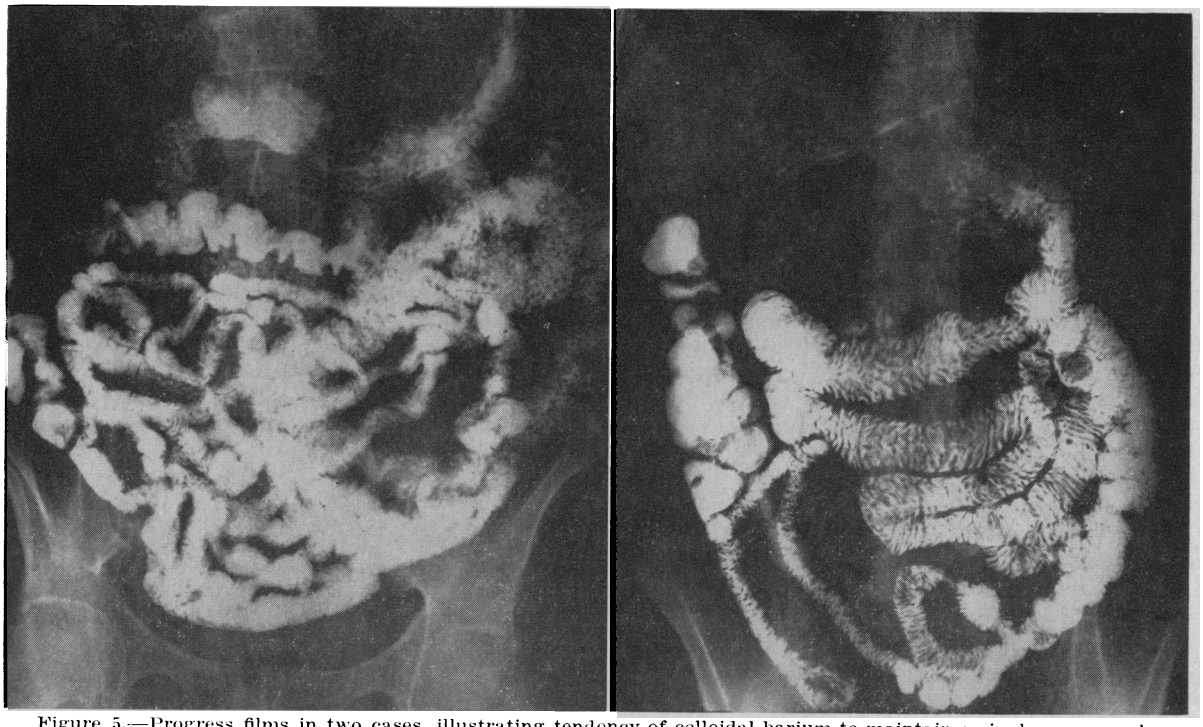

Figure 5.—Progress films in two cases, illustrating tendency of colloidal barium to maintain a single opaque column from the stomach or upper small intestine into the colon.

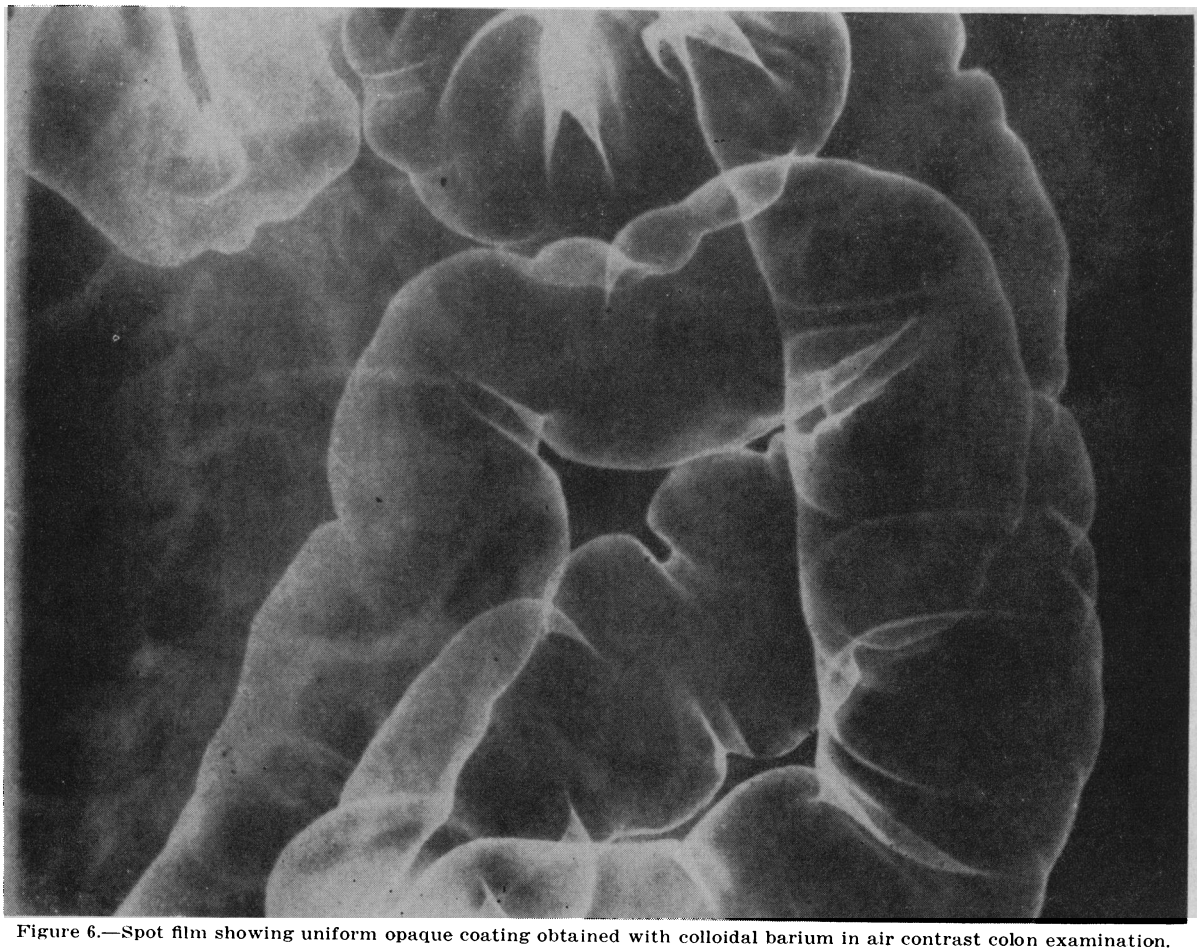

Figure 6.—Spot film showing uniform opaque coating obtained with colloidal barium in air contrast colon examination.

viscous preparation usually employed in gastric examinations has been used. This material will not fill the colon by gravity flow; it may be "milked" along the enema tube or injected with a large piston-type syringe. Air is then pumped into the colon with the conventional rubber bulb and bag and the patient is so manipulated as to facilitate the distribution of the opaque medium. The inflated, barium-coated bowel is easily visualized fluoroscopically when the viscous medium is used, and spot films may be made selectively over any desired segment.

With proper technique, the colloidal medium provides a thin, uniform, smooth coating of homogeneous character (Figure 6). A number of polyps measuring less than 1 cm. in diameter have thus been detected and verified. Satisfactory examinations have resulted from the use of the new medium in this procedure much more consistently than with simple barium-water mixtures. However, it cannot yet be stated that the colloidal material will enable the detection of a significantly greater proportion of polyps than has hitherto been possible.

DISCUSSION

Completely objective evaluation of a radiographic opaque medium is not really possible. Nevertheless, it is felt that the "blind" method of analysis of parallel test and control cases has eliminated many major sources of subjective error in this study. The evidence indicates that the colloidal medium is superior to simple barium-water mixtures in demonstrating the mucosal surface of the small intestine and duodenal bulb, in coating the colon during air contrast examinations, and in its resistance to precipitation by gastric secretions. These results are preliminary, and much more experience with this medium will be necessary before a definitive evaluation can be attempted. Nevertheless, they encourage the hope that further investigation will soon yield an optimal opaque medium for gastrointestinal examination.

REFERENCE

1. Jones, H. H., Kaplan, H. S., and Windholz, F.: Air contrast colon examination with colloidal barium (manuscript in preparation).